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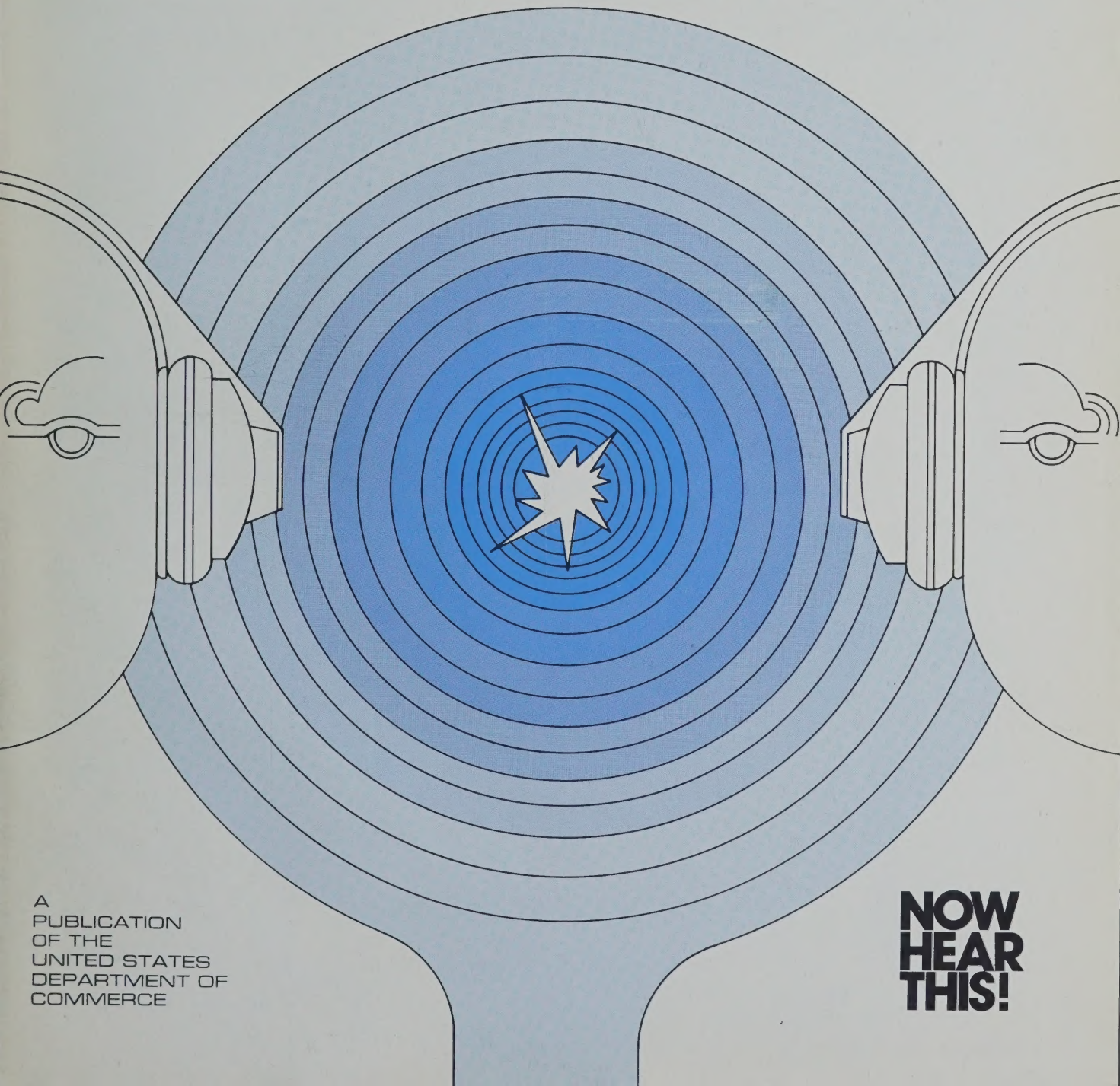
DIMENSIONS NBS



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NATIONAL BUREAU OF STANDARDS

DIMENSIONS NBS

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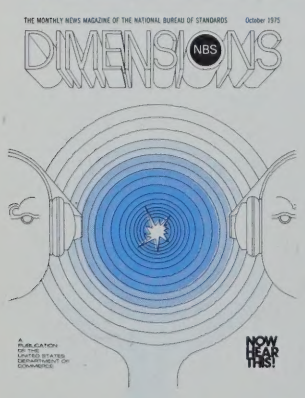

COVER: Sharpshooters on the practice range may unknowingly be doing damage to their hearing. For a discussion of the problem and its solutions, see the story beginning on the opposite page.

The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:
The Institute for Basic Standards
The Institute for Materials Research
The Institute for Applied Technology
The Institute for Computer Sciences and Technology
Center for Radiation Research
Center for Building Technology
Center for Consumer Product Technology
Center for Fire Research
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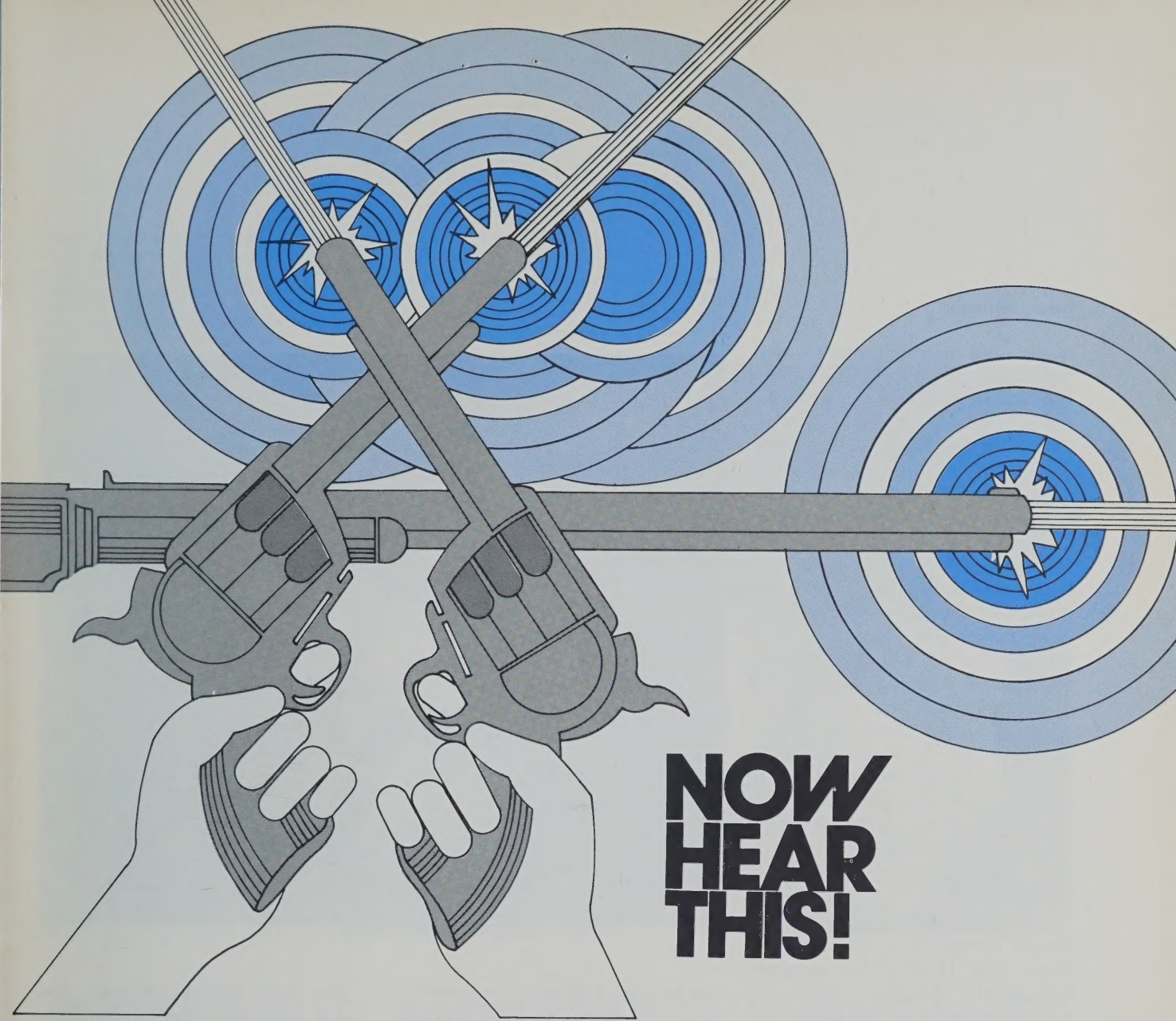

NOW HEAR THIS!

PROTECT YOUR EARS... OR DON'T SHOOT

Sounds much less intense than gunfire can cause a gradual hearing loss. The process is rarely painful and the hearing loss may pass unnoticed—until it is too late.

Gunfire noise—as measured in National Bureau of Standards research involving the firing of nine popular weapons — typically exceeds safe levels by considerable margins, going as high as 171 dB.

The meaning is clear: If your profession or avocation brings you regularly to the firing range, you are a member of a high-risk group. On the range, you should never be without hearing protectors.

ON the practice range, there is one kind of direct hit that all shooters score 100 percent of the time, regardless of individual skill. Each bullet fired has a crashing impact on the ears of the person holding the gun or anyone nearby.

Children at play always say *bang-bang!* as they carry the battle to the enemy, and society at large is well aware of noise as the most obvious immediate manifestation of gunfire. Yet the real effects of gunfire sounds on the human auditory system are little understood or appreciated.

Laboratory and firing range blast-wave measurements show that com-

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This police marksman, by wearing protective earmuffs, is minimizing risk of temporary or permanent hearing impairment as he practices on the firing range.

monly used firearms menace unprotected ears with severe trauma that can result in temporary or permanent deafness. This conclusion remains firm regardless of individual differences in hearing damage susceptibility and is based on criteria established by responsible government agencies.

Hearing protection is called for under the Occupational Safety and Health Act (OSHA) for any private industry or Federal workers who are even momentarily exposed to noise levels exceeding 140 decibels (dB). (The decibel is most commonly used to express sound pressure levels. In terms of human hearing, 0 decibels represents the threshold of hearing. For various kinds of home appliances, lawn care, and shop tools, the sound pressure level may approach 80 dB. At a rocket launching, the level is about 180 dB. OSHA requirements begin at 90 dB.

Last year, the Environmental Protection Agency (EPA) recommended lowering by 12 dB a 1968 proposed Damage-Risk Criterion (DRC) for daily exposure to gunfire noise. The criterion, drafted by the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) of the National Academy of Sciences-National Research Council, proposes maximum safe peak pressure levels, in dB, for noise impulses of a given duration. Above the DRC maximum level, hearing protectors should be worn.

That gunfire noise is characteristically too loud for hearing safety has been demonstrated in research sponsored by the National Institute of Law Enforcement and Criminal Justice, Department of Justice.

Working with weapons ranging from 9 mm automatics to 12 gauge shotguns, physicists Pearl G. Weissler and Michael T. Kobal of the National Bureau of Standards, in a series of laboratory and firing range experiments, measured and compared peak pressure levels and signal durations with OSHA, CHABA, and EPA criteria. The Weissler-Kobal team, from the NBS Sound Section, Institute for Computer Sciences, concluded:

". . . that on an indoor firing range with sound-absorbing booths for each shooter, the noise output of all the guns . . . except the caliber .22 rifle . . . exceeds the CHABA Basic DRC, while the noise output of all the firearms tested exceeds the EPA [maximum] levels. In more reverberant firing ranges, the noise output of the caliber .22 rifle also exceeds the CHABA Basic DRC."

On these findings Weissler and Kobal based their strong recommendation for "use of hearing protectors for all indoor and outdoor practice shooting with the possible exception of the caliber .22 rifle when outdoors and far from buildings and reflecting surfaces with no other shooter present."

What kind of hearing protectors?

Ronald C. Dobbyn, protective equipment program manager for the NBS Law Enforcement Standards Laboratory (LESL), with LESL Chief Jacob J. Diamond, has directed the preparation of a *Selection Guide to Hearing Protectors for Use in Firing Ranges.* This user guideline is to be published by the Justice Department's Law Enforcement Assistance Administration

Earmuffs are preferred by many who frequent the range, while earplugs are the protective device chosen by others. Advantages and disadvantages of each form of protection relate to such considerations as comparative costs, ease of fitting, and personal comfort and convenience.

(LEAA) through LEAA's National Institute of Law Enforcement and Criminal Justice.

In view of the ever-present danger of temporary or permanent hearing damage that gunfire noise presents, the LESL specialists emphatically declare that there is no substitute for good hearing protectors. The cost is negligible when compared with the cost of potential deafness to the individual.

All high-risk groups—including law enforcers, the military, hunters, and target-shooting sports competitors—should know the basic types of available hearing protectors and choose wisely among them to meet personal requirements. Where gunfire noise is a regular part of one's routine, its sound pressure cannot ordinarily be reduced to safe levels by sound-proofing of walls or similar expedients. Nor is the use of gun silencers an option, since it is illegal to silence any gun. Hearing protectors represent the only practical approach.

More than 30 U.S. manufacturers market earplugs, earmuffs, and helmets as hearing protectors. Plugs and muffs are most popular; helmets may be regarded simply as a special kind of muff.

Industrial noise experts have listed advantages and disadvantages of various hearing protection devices. For example, earplugs are easily carried and stored, but they can just as easily be left in the "other" suit of clothes, lost from a pocket, or dropped while being placed in the ear. Ear canals vary in diameter (from about 3 to 14 mm) and left and right canals may not be the same size or shape—the same individual may actually require differently designed plugs for each ear. As an alternative, one may use putty-like formable plugs that change their contours to fit any ear canal, but such plugs require frequent replacement. Earplugs can be used with glasses, earrings, any hair style, and any type of hat without affecting their performance. But they should be worn only in "healthy" ears. Properly seated earplugs cannot be seen at a distance. Supervisors must be trained to recognize the appearance of a properly seated earplug at a glance.

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ENERGY STRATEGIES
FOR HEALTH CARE INSTITUTIONS

AT a regional conference for health care administrators in Denver, Colo., on August 11, 1975, Dr. F. Karl Willenbrock, Director of NBS' Institute for Applied Technology, offered some very practical advice for administrators seeking to reduce energy costs. His examples were obtained from NBS experience with its Energy Conservation Program Guide for Industry and Commerce (EPIC) and with the Modular Integrated Utility System (MIUS) concept being studied by the Department of Housing and Urban Development. Excerpts from Willenbrock's speech follow:

Energy conservation strategies for health care administrators can take many forms. They can be in the form of an individual effort, or they can be a group undertaking. But no discussion of health care institutions would be complete without considering energy conservation in buildings. From an overall national standpoint, roughly one-third of the energy consumed in the U.S.A. is used to provide building services, that is, heating and cooling, lighting, heating water, and so forth. On the basis of work done at the National Bureau of Standards and elsewhere, we estimate that a major fraction of this energy is wasted.

The energy use in a building is determined by three factors. First, design is a crucial factor. The glass curtain wall constructions used in many modern buildings in large cities are examples of structures that use large amounts of energy.

Construction a Factor

Second, the actual construction of the building helps determine its energy consumption. A well-designed

building from a thermal standpoint will still use a lot of energy if the thermal materials are not properly installed. With the use of modern thermography, it is possible to examine a fully-installed wall structure to see how well it is insulated. Such techniques help to identify failures in execution.

Finally, the way a building is maintained and operated can have an enormous impact on energy use. You can have the best designed, best constructed building in the world, and it can still be a high consumer of energy if it is improperly maintained or operated.

Let's start with the recognition that the energy shortage is real. The question no longer is whether there will be an energy shortage but rather how we can best use our limited resources with the least discomfort and disruption in our daily lives.

Until the time, which is still some years away, that the United States achieves additional sources of energy, the answer lies in energy conservation. The wise use of those fuels we have can minimize greatly the effects of energy shortages.

Wide Spectrum of Institutions

The energy shortage has particularly impacted the Nation's health care institutions. Such institutions cover a wide spectrum from nursing homes in converted dwellings to major campus-type operations that have many aspects of small cities. Energy uses and the ability to conserve energy in these institutions also cover a wide variety of situations and capabilities. You can generalize, however, and recognize that hospitals and other health care facilities are, by their very nature, heavy users of energy and, normally, very susceptible to energy conservation measures.

EPIC emphasizes the importance of top management commitment to energy conservation and assigning responsibility for coordinating energy conservation to a top level, knowledgeable individual. The Guide provides the coordinator with a plan for surveying energy use and with information on the various techniques of energy flow measurement. Where additional outside help may be required, sources of assistance are listed in a special section.

The Guide also provides a checklist of over 180 energy conservation opportunities suggesting ways for reducing or using energy more efficiently. The checklist suggestions run the gamut from the very simple to the most complex and are divided according to usage in buildings and grounds, electric power, steam, other utilities, heat recovery and confinement, combustion, scheduling of work, materials handling and shipping, and commercial practices.

Tennessee Hospital's Application

Although the EPIC Kit was designed for business use, a private hospital in Tennessee applied the EPIC manual and achieved a 39½ percent reduction in electrical consumption. A Veterans Administration Hospital, with the assistance of a consulting engineer from a local university, is using EPIC as a guide to initiate four energy-saving projects, all of them concerned with the heating of buildings.

In the first project, the hospital management replaced hallway thermostats with some 1,300 individual room thermostats, each one pre-set to 20 °C (68 °F). The hallway thermostats caused temperatures to vary from room to room with an overall average of about 22 °C (72 °F). The reduction to a uniform 20 °C (68 °F) is expected to result in a saving of approximately 10 to 12 percent of the heating bill, the precise amount depending on the efficiency of the heating system.

In the second project, hospital management installed a zone control system to better direct heat and air conditioning to different parts of the building where needed. This system permits channeling more heat to outside rooms and less to the inner core of the building in the winter. In the summer, the system permits sending more cold air to the sunny side and less to the shady side of the building. The managers of an IBM office building in Chicago report that such a system was one of the major contributors to reducing the heating bill of their building by 50 percent in the 1973-74 season. The savings achieved by the VA hospital have not yet been reported, but a substantial saving in the heating and air conditioning costs is expected.

Focus on Ventilation

In the third project, hospital management focused on ventilation. Since the hospital operating rooms and the research buildings must, for ventilating purposes, exhaust large quantities of warm air in winter and cool air in summer, the exhaust duct-work was rearranged so that it was side-by-side with the duct carrying the incoming air. A heat exchanger was installed between the two. Thus, the outgoing air exchanges heat with the incoming air and about 75 percent of the heat or a corresponding amount

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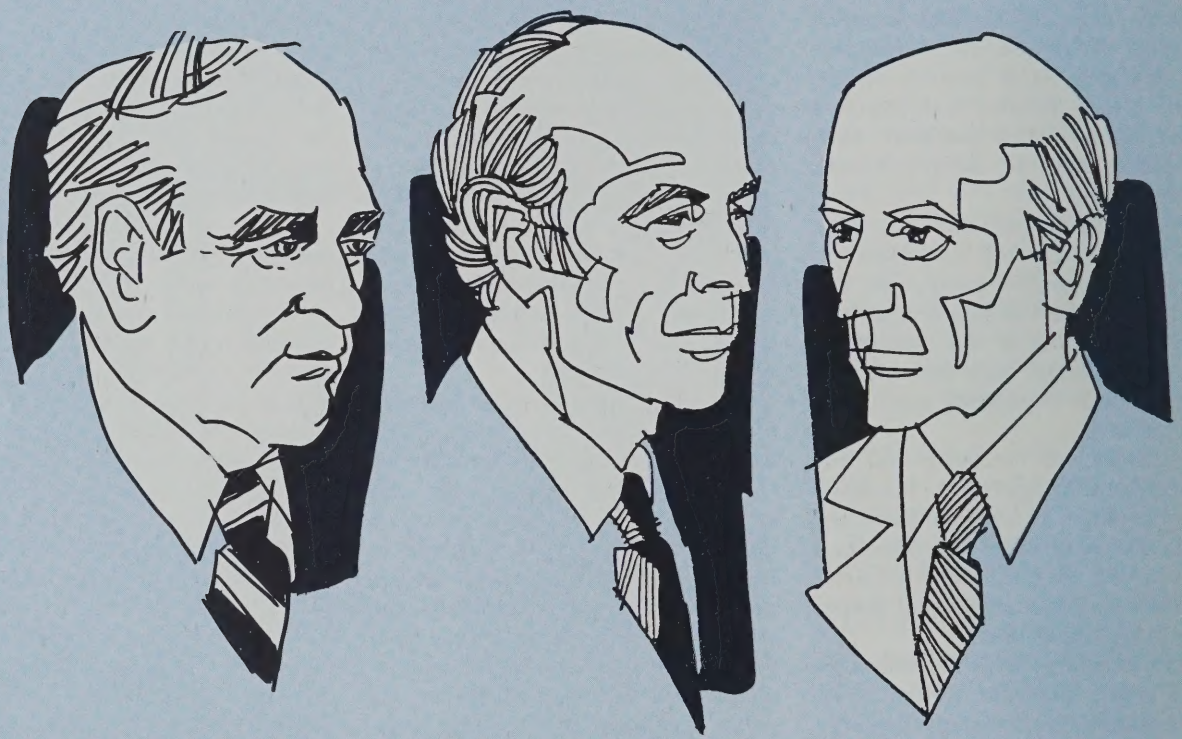
An International Meeting, A Century Celebration

Mixing business and pleasure, delegates from 43 nations to the 15th General Conference on Weights and Measures joined French President Valery Giscard d'Estaing and other high French officials in celebrating 100 years of the Treaty of the Meter (DIMENSIONS/NBS, May 1975).

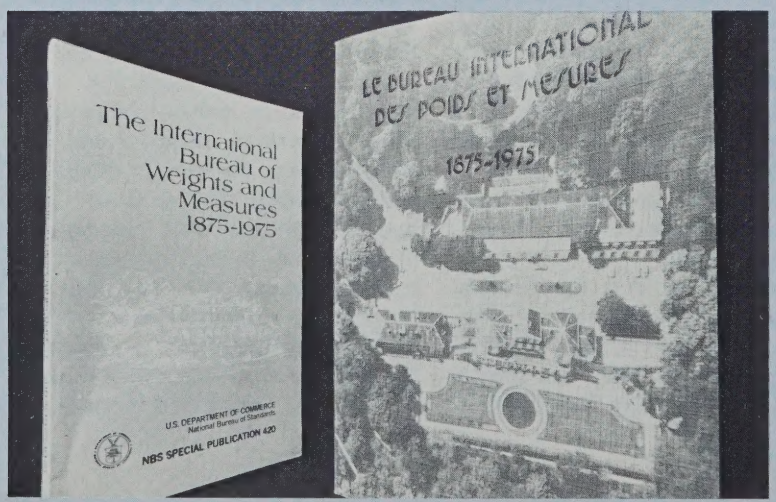
The three bodies created under the Treaty, including the oldest world research organization, the International Bureau of Weights and Measures, are discussed in a centennial volume. The volume is shown below with its companion document, an English translation from the National Bureau of Standards.

Revisions in the metric system were one item of business at the 15th General Conference. For a discussion of these revisions and what they mean to a metric world, see the following article.



Among the participants at a Treaty of the Meter centennial celebration held at the Elysee Palace were, from left, NBS Acting Director Ernest Ambler, delegate to the General Conference, member of the International Committee for Weights and Measures, and head of the Committee's Consultative Committee on Ionizing Radiation; French President Valery Giscard d'Estaing, host of the ceremonies; and Jean Terrien, current head of the International Bureau of Weights and Measures. Former NBS Director Richard W. Roberts led the U.S. delegation to the 15th General Conference.

A commemorative medal shows the Pavillon De Breteuil, located near Paris, where the International Bureau of Weights and Measures—the oldest international scientific laboratory—is housed.



The English translation of the centennial volume on the International Bureau of Weights and Measures can be obtained through the Government Printing Office, Washington, D.C. 20402. Order prepaid ($3.00) and give catalog number C13.10:420.

World Conference Updates Vocabulary of Measurement Science

Adds new prefixes for SI units. Adopts special names for radiology units. Recommends value for the speed of light.

THE language of science, like any living language, constantly changes. As advances are made in science and technology, new words are needed to describe new phenomena or better describe old ones.

Even in measurement science, where uniformity and stability are the name of the game, the 15th General Conference on Weights and Measures, meeting in Paris May 27-June 3, found it necessary to add several new items of vocabulary. These changes reflect interactions of physical measurements with economics (world energy problems) and medicine (radiology).

Meeting once every 6 years or sooner (the last time was in 1971), the General Conference is the diplomatic body that supervises the work of the International Bureau of Weights and Measures. It is also the tribunal where decisions are made about the International System of Units (SI)—better known as the metric system—decisions to adopt new units or standards or vocabulary or to modify old ones.

For the technical basis of its decisions, the General Conference relies largely on the reports and recommendations of the International Committee for Weights and Measures, a group of scientists from countries (including the United States) that adhere to the Treaty of the Meter. The International Committee also directs the scientific program of the International Bureau.

SI Prefixes

For those who have just become used to the sound of such metric prefixes as *deci, centi* and *kilo,* there are two new prefixes to try out: *peta* (symbol P) for 10^{15} and *exa* (symbol E) for 10^{18}. *Peta* is pronounced as in "petal" and *exa* as in "Texas."

The use of these prefixes is part of one of the best known and most convenient features of the SI or metric system—its use of decimal multiples and submultiples of the different units, expressed by adding certain prefixes to the names of the units. One has, for example, 10 decimeters = 1 meter, 100 centimeters = 1 meter, 1 nanometer = 10^{-9} meter, 1 kilometer = 1000 meters, and so on.

The two new prefixes adopted by the General Conference simplify the handling of very large quantities. It was pointed out, in particular, that they would encourage greater use of the SI unit of energy, the *joule* (symbol J), instead of non-SI units like the *watthour* (1 watthour = 3600 J) for expressing the large amounts of energy that enter into current discussions of national and world energy problems. The terajoule (10^{12} J), it was noted, is often too small and therefore "a stumbling block to the use of SI."

Example: According to a recent estimate, the total amount of energy from hydroelectric, fossil-fuel, nuclear, and geothermal sources that is currently delivered to consumers in the United States each day is about 100 petajoules (in symbols: 100 PJ) or, equivalently, 0.1 exajoule (in symbols: 0.1 EJ). That is, about 1 exajoule of energy is delivered every 10 days.

SI Radiology Units

The Conference also adopted special names for the SI units of activity and absorbed dose.

The SI unit of activity of a radioactive source, equal to 1 disintegration or other nuclear transformation per second, is to be called the *becquerel* (symbol Bq). It is named in honor of Henri Becquerel, the French physicist who discovered radioactivity in 1896.

It was argued that the previous symbol "s^{-1}" for the SI unit of activity, because of the negative exponent, is "inconvenient and consequently dangerous in most current applications, especially in hospitals." The name *becquerel,* with its symbol Bq, avoids this difficulty. In conjunction with the new prefixes, the *becquerel* should encourage users to replace *curie (1 curie* $= 3.7 \times 10^{10}$ Bq)

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by the SI unit when describing intense radioactive sources such as are used to sterilize foods.

The SI unit of absorbed dose, defined as 1 joule per kilogram (symbol $J.kg^{-1}$), is to be called the *gray* (symbol Gy). As an example, a patient receives 1 gray when ionizing radiation imparts one joule of energy to one kilogram of tissue. The name honors Louis Harold Gray, the British radiobiologist whose studies laid the foundation for the use of ionization chambers in measuring absorbed dose.

Use of the term *gray* has advantages similar to those of the *becquerel*. It too eliminates the use of a symbol containing a negative exponent and, in addition, it avoids the potential danger that unsophisticated medical users might misinterpret the "kilogram" in "joules per kilogram" to refer to the total weight of the patient. Adoption of the term gray is expected to help the SI unit of absorbed dose displace the *rad* (1 rad=0.01 joule per kilogram).

Centennial

Coinciding very nearly with its own 100th birthday as well as that of the International Bureau, the 1975 meeting of the General Conference lived up to its century-long tradition of keeping measurement standards and techniques in step with the vanguard of science and technology.

Besides adding to the vocabulary of measurement, the Conference adopted a number of resolutions that provide glimpses of major lines of research in metrology at the highest levels of accuracy and precision now going on, or being planned, at the International Bureau and at national laboratories like the U.S. National Bureau of Standards. The resolutions dealt with units and standards of physical quantities that are basic to the metric system: length, mass, time, electricity, temperature.

Length, Mass

The first resolution gave official recognition to the successful efforts to develop gas lasers whose wavelengths are stabilized to an absorption line. Such lasers are now available and could provide the basis for a new standard of length with a substantially higher intrinsic precision than the present krypton-86 standard.

The Conference decided, however, that to redefine the meter in terms of presently available lasers would be premature because there was a good chance that further research would soon produce even better lasers for the purpose. It urged the national laboratories and the International Bureau to continue their researches in this direction and asked the International Committee to coordinate the research.

A companion resolution recommended the general adoption of $c = 299\ 792\ 458$ m/s as the speed of light in vacuum. The recommendation to use this particular value (whose accuracy is limited mainly by the degree of reproducibility of the krypton-86 standard) was made in the expectation that when the meter is eventually redefined, it will be done in a way that leaves the speed of light unchanged. Possibly, the speed of light will be fixed by definition, so that the meter would be determined by this value and the length of the atomic second—that is, the meter would be defined as the distance traveled by light in a specified time. (These possibilities, as well as current research on stabilized lasers, were described in DIMENSIONS/NBS, April 1974, p. 88).

The agenda for the Conference stated that "this fundamental constant [the speed of light] is most likely the most important one there is in physics" and pointed out that it is critically involved in determinations of electrical standards and in measurements of distance by radar techniques. "The universal use of the same value for this constant is thus eminently desirable in practice and science."

Research on mass standards and methods for comparing them, the Conference noted, appeared to be lagging behind what was being done in other areas, and the International Bureau had already initiated a survey of the situation. Considering that "for the moment, no method is foreseen which will make it possible to define the unit of mass in terms of atomic constants with an equivalent accuracy [to that of the Prototype Kilogram]," the Conference strongly recommended that national laboratories and the International Bureau "pursue studies which aim at improving the accuracy of mass standard comparisons."

Time

In the area of time measurement, the Conference centered its attention on the work of the International Bureau of Time (BIH). The BIH, located at the Observatory of Paris, has been in operation since 1919, when it began coordinating the time signals broadcast by radio stations around the world.

With the advent of the atomic clock and the 13th General Conference's adoption of the "atomic sec-

ond" as the unit of time interval in 1967, the BIH began to disseminate a time scale, International Atomic Time (TAI), based on the atomic second rather than on the less uniform rotation of the earth. By occasionally (twice a year at most, usually only once or not at all) omitting a second or inserting an extra one ("leap" second) in the TAI scale, experts adequately approximate the astronomical scale that is so convenient, and probably indispensable, for everyday purposes. This new scale is the widely used Universal Coordinated Time (UTC).

The 15th General Conference expressed satisfaction with the way the BIH has been maintaining and disseminating the International Atomic and Universal Coordinated time scales. It also noted that UTC is now used for civil purposes everywhere in the world. Despite this, local laws concerning "standard" and "daylight saving" times in some places still refer to the astronomically based Greenwich Mean Time (GMT), an anachronism the Conference would like to see eliminated.

Electrical Standards

After a brief survey of the work being done on electrical standards, the Conference gave its blessing to several lines of research in progress. It again emphasized the need to improve the determination of the ampere and to continue measurements of the gyromagnetic ratio of the proton as a way of tying the electrical standards to atomic constants.

Three recommendations of the Consulative Committee for Electricity, even though submitted too recently for the Conference to discuss them, are of interest to precision electrical measurements laboratories.

The first of these recommendations recognizes that the most accurate realizations of the ohm are those recently constructed in several national laboratories by means of the Lampard-Thompson calculable capacitor, and asks that the ohm standard at the International Bureau be brought into agreement with these improved standards.

It was recommended secondly that steps be taken to improve the stability and transportability of Weston cells to more nearly match the increased constancy with which volt standards can be maintained by the use of the Josephson effect.

Lastly, it was recommended that efforts be intensified to improve the absolute measurement of the volt and ampere, either by improving existing methods or by finding new ones, such as determining 2e/h on the basis of other atomic constants, but independently of volt standards, and thus creating (via the Josephson effect) a new volt standard.

Temperature

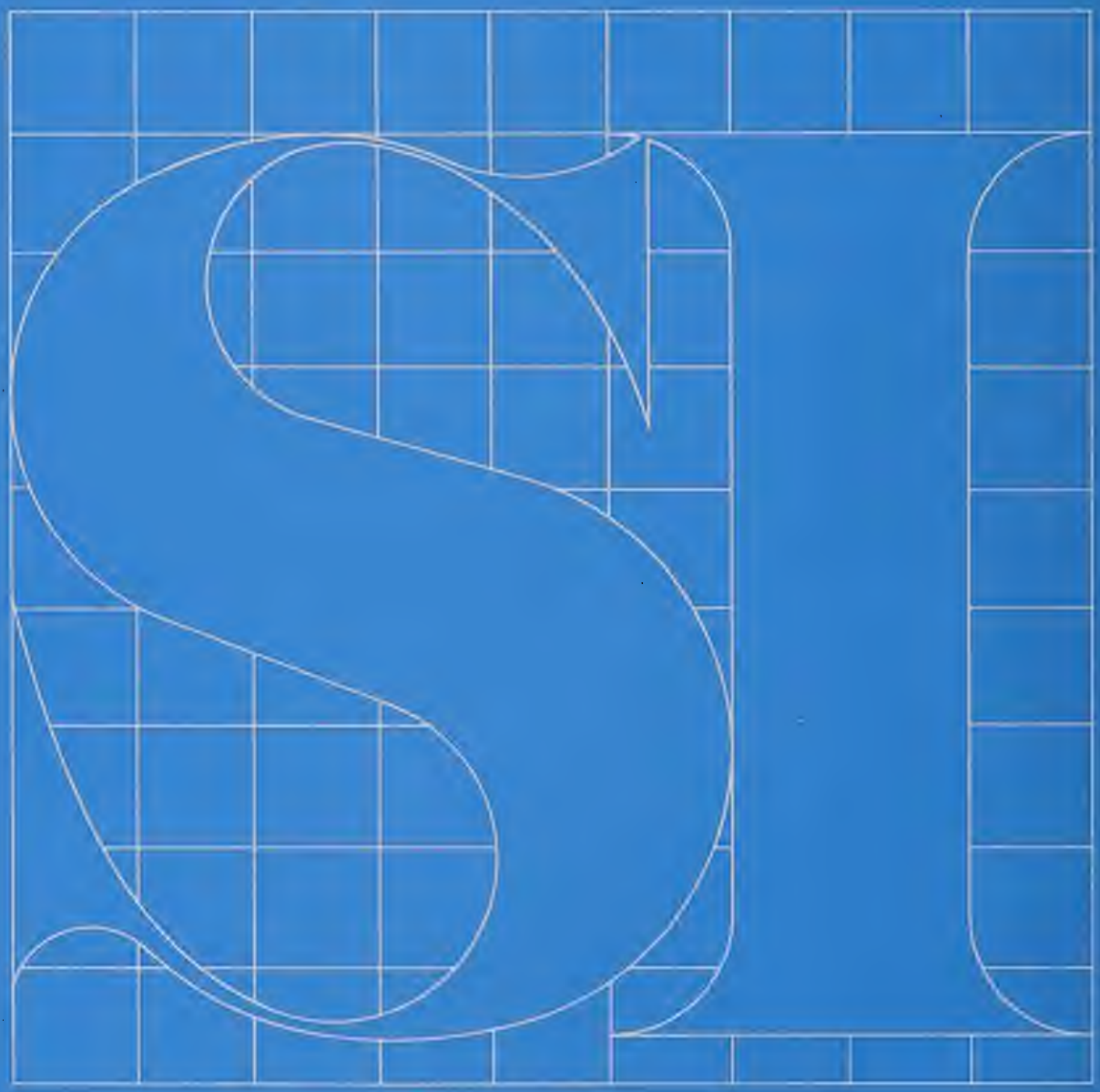
The Conference approved recent changes made in the International Practical Temperature Scale (IPTS) which improve its convenience and reproducibility. At the same time, the International Bureau was asked to carry out another major revision of the scale to improve its accuracy by providing values still closer to thermodynamic temperatures.

First adopted by the 7th General Conference in 1927, the IPTS was, and still is, based on a set of instruments for different temperature ranges (platinum resistance thermometer, platinum-rhodium thermocouple, pyrometer) which are to be constructed and used in a specified way, and on the carefully measured thermodynamic temperatures of a series of "fixed points"—freezing, boiling, or triple points—of certain substances. Major improvements in the IPTS were made in 1948 and 1968 The version approved by the 15th General Conference will be known as the "1975 edition of the IPTS of 1968." □

The International Practical Temperature Scale is based in part on the carefully measured thermodynamic temperatures of a series of "fixed points"—freezing, boiling, or the triple points of certain substances. Under specified conditions, water in the triple point cell shown above is maintained simultaneously in 3 states: the freezing, boiling, and vapor points.

Metric Vocabulary

A Reference Guide



The National Bureau of Standards is the Nation's official source of information on the International System of Units (SI), more commonly known as the metric system.

As such, NBS offers the following tables and notes to assist the growing numbers of SI users.

The terminology below is a comprehensive listing of the vocabulary of SI. Companion charts and further information, both technical and general, are available through the Metric Information Office, National Bureau of Standards, Washington, D.C. 20234.

—SI units

Quantity	Name	Symbol
	SI BASE UNITS	
length	meter (metre)[1]	m
mass[2]	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature.[3]	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd
	SI SUPPLEMENTARY UNITS	
plane angle	radian	rad
solid angle	steradian	sr

[1] Both spellings are acceptable.
[2] "Weight" is the commonly used term for "mass."
[3] It is acceptable to use the Celsius temperature (symbol t) defined by $t = T - T_0$ where T is the thermodynamic temperature, expressed in kelvins, and $T_0 = 273.15$ K by definition. The unit "degree Celsius" is thus equal to the unit "kelvin" when used as an interval or difference of temperature. Celsius temperature is expressed in degrees Celsius (symbol °C).

Units for all other quantities are derived from the above nine units. The following table lists 17 SI derived units with special names which are formed from the base and supplementary units in a coherent manner. That is, in brief, the derived units are expressed as products and ratios of the nine base and supplementary units without numerical factors.

—SI derived units with special names

Quantity	SI unit: Name	Symbol	Expression in terms of other units
frequency	hertz	Hz	s^{-1}
force	newton	N	$m \cdot kg/s^2$
pressure, stress	pascal	Pa	N/m^2
energy, work, quantity of heat.	joule	J	$N \cdot m$
power, radiant flux	watt	W	J/s
quantity of electricity, electric charge.	coulomb	C	$A \cdot s$
electric potential, potential difference, electromotive force.	volt	V	W/A
capacitance	farad	F	C/V
electric resistance	ohm	Q	V/A
conductance	siemens	S	A/V
magnetic flux	weber	Wb	$V \cdot s$
magnetic flux density	tesla	T	Wb/m^2
inductance	henry	H	Wb/A
luminous flux	lumen	lm	$cd \cdot sr$
illuminance	lux	lx	lm/m^2
activity (radioactive).	becquerel	Bq	s^{-1}
absorbed dose	gray	Gy	J/kg

All other SI derived units, such as those in the following two tables, are similarly derived in a coherent manner from the 26 base, supplementary, and special-name units.

—Examples of SI derived units, expressed in terms of base units

Quantity	SI unit	Unit symbol
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s
acceleration	meter per second squared.	m/s^2
wave number	1 per meter	m^{-1}
density, mass density.	kilogram per cubic meter.	kg/m^3
current density	ampere per square meter.	A/m^2
magnetic field strength.	ampere per meter	A/m
concentration (of amount of substance).	mole per cubic meter.	mol/m^3
specific volume	cubic meter per kilogram.	m^3/kg
luminance	candela per square meter.	cd/m^2

—Examples of SI derived units expressed by means of special names

Quantity	Name	Unit symbol
dynamic viscosity	pascal second	$Pa \cdot s$
moment of force	meter newton	$N \cdot m$
surface tension	newton per meter	N/m
heat flux density, irradiance.	watt per square meter.	W/m^2
heat capacity, entropy.	joule per kelvin	J/K
specific heat capacity, specific entropy.	joule per kilogram kelvin.	$J/(kg \cdot K)$
specific energy	joule per kilogram	J/kg
thermal conductivity.	watt per meter kelvin.	$W/(m \cdot K)$
energy density	joule per cubic meter.	J/m^3
electric field strength	volt per meter	V/m
electric charge density.	coulomb per cubic meter.	C/m^3
electric flux density.	coulomb per square meter.	C/m^2
permittivity	farad per meter	F/m
permeability	henry per meter	H/m
molar energy	joule per mole	J/mol
molar entropy, molar heat capacity.	joule per mole kelvin.	$J/(mol \cdot K)$

For use with the SI units there is a set of 16 prefixes (see below) to form multiples and submultiples of these units. It is important to note that the kilogram is the only SI unit with a prefix. Because double prefixes are not used, the prefixes in the following table are to be used with the gram rather than with the kilogram.

—SI prefixes

Factor	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Certain units which are not part of the SI are used so widely that it is impractical to abandon them. The units that are accepted for continued use in the United States with the International System are listed in the following table.

—Units in use with the international system

Name	Symbol	Value in SI unit
minute	min	1 min = 60 s
hour	h	1 h = 60 min = 3 600 s
day	d	1 d = 24 h = 86 400 s
degree	°	$1° = (\pi/180)$ rad
minute	′	$1' = (1/60)° = (\pi/10\ 800)$ rad
second	″	$1'' = (1/60)' = (\pi/648\ 000)$ rad
liter (litre)[1]	l	1 l = 1 $dm^3 = 10^{-3}$ m^3
metric ton or tonne	t	1 t = 10^3 kg

[1] Both spellings are acceptable.

In those cases where their usage is already well established, the use, for a limited time, of the following units is accepted, subject to future review.

nautical mile	hectare	gal [1]
knot	barn	curie
angstrom	bar	rontgen
standard atmosphere	are	rad

[1] Not gallon.

Metric units and their symbols other than those enumerated above are not part of the International System of Units. Accordingly, the following units and terms listed in the table of metric units in section 2 of the act of July 28, 1866, that legalized the metric system of weights and measures in the United States, are no longer accepted for use in the United States:

myriameter
stere
millier or tonneau
quintal
myriagram
kilo (for kilogram)

HIGHLIGHTS

New Energy Guide Labels

Energy Guide labels have been developed which show the energy use and dollar cost of electricity to operate refrigerators, combination refrigerator/freezers, and freezers on a monthly basis. The labels, which will be attached to household refrigeration appliances by individual manufacturers on a voluntary basis, are the latest step in the Commerce Department's broad voluntary energy conservation program for home appliances. The labels will show the energy consumption in kilowatt hours and the dollar cost of electricity to operate the appliance on a monthly basis. This information will permit customers to compare the operating costs of various models.

Transformation of Cadmium

An NBS research team has discovered the possibility that cadmium may be transformed from a relatively harmless inorganic form to a highly toxic volatile form by a microorganism in an aquatic environment. Further, the researchers have found that the volatile cadmium species reacts with Hg(II) to form dimethylmercury under certain laboratory conditions.

Residual Oil SRM

Trace Elements in Residual Fuel Oil has been issued as a Standard Reference Material (SRM 1634). Because of the increasing interest on the effects of trace elements emitted into the atmosphere, and the need for standards in promoting the Clean Air Act, SRM 1634 should provide a firm basis for the accuracy of the required analyses. It is intended to be used in: (1) analysis of fuel oils and other materials with similar matrices for trace element content; (2) development or refinement of analytical procedures; and (3) interlaboratory-comparison experiments. SRM 1634 supplements previously issued SRM's 1632, Trace Elements in Coal, and 1633, Trace Elements in Coal Fly Ash.

Magnification SRM

NBS has produced and calibrated a specimen design that will give an accurate, stable, and high contrast magnification standard for the scanning electron microscope (SEM). The SEM provides a large depth of field and easily interpreted images of samples that often require little or no sample preparation for viewing. This specimen design will be issued with recommended measurement procedures as a SEM Magnification SRM in the near future.

Atmospheric Chemistry Publication

NBS Technical Note 866, "Chemical Kinetic and Photochemical Data for Modelling Atmospheric Chemistry," has recently been released. The document contains a table of data on rates of gas phase chemical reactions and on the photochemistry of neutral species. It is intended to provide the basic physical chemical data needed as input for calculations modelling atmospheric chemistry. It is available from the U.S. Government Printing Office, Washington, D.C. 20402, SD Catalog No. C13.46:866, $1.85.

Advances in Frequency Measurements

Researchers at the NBS Boulder labs have extended the realm of directly measurable laser frequencies to new heights. The accomplishment is the latest in a continuing series of laser frequency measurements which has now achieved 147.915 850 THz (147.915 850 X 10^{12} Hz) with a probable error of one part in 10 million. This frequency is only a factor of three below the red end of the visible spectrum, which is the next NBS target. The measurement of a frequency in the near infrared was carried out to demonstrate the feasibility of the technique and was done without the benefit of stabilized lasers. Had stabilized lasers been used, the accuracy could have been improved to the level of a part in 10 billion or better.

While the wavelength of radiation can be measured at higher frequencies, such measurements are inherently much less accurate than direct frequency measurements of the kind described here, which are ultimately traceable to NBS standards of frequency. □

CODATA Conference

The fifth biennial conference of the Committee on Data for Science and Technology (CODATA) of the International Council of Scientific Unions will be held June 28-July 1, 1976 at the University of Colorado, Boulder, Colo. The conference will cover: methodology of data evaluation; procedures for correlating, extrapolating, and estimating data; data needs for technological impact assessment, process design, energy and environmental research, and other areas; descriptions of data collection and publication activities; and machine techniques for storage, retrieval, and dissemination of numerical data. Contact Dr. David R. Lide, Jr., NBS, Washington, D.C. 20234.

NBS Tests Six-Axis Robot

INDUSTRIAL robots are making gains in productivity and job safety in a wide range of applications around the world. Approximately 2,000 such robots now operate machines and work on assembly lines at hazardous and tedious tasks in manufacturing plants. Productivity increases and improvements in work quality and safety laws, such as the Occupational Safety and Health Act, are major motivating forces behind the introduction of robot systems.

Newer generations of robots with vision and tactile sensors promise even more versatility and efficiency.

The NBS Office of Developmental Automation and Control Technology is using a new six-axis manipulator system for research on sensor and control technologies and development of performance evaluation techniques. This research robot, called the Scheinman Arm after its designer, Vic Scheinman of Stanford University, is electrically-powered and intended to be operated under computer control. The robot has become a standard for research in automation and artificial intelligence.

The NBS robot will be equipped with sensors to allow it to perform properly even with uncertainties in its environment. The robot will then be used as a test bed for the development of performance measurement techniques for robot systems.

The robot will be used in the NBS Instrument Shops Division as well as in the DACT lab to investigate interfaces between robots and machine tools. The Scheinman Arm will also be used for the development of standard computer control languages for industrial robot systems and numerically controlled machine tools.

The robot has six different motions. The first three—shoulder swivel, arm up and down, arm reach out and in—are an offset spherical coordinate system to position the hand. The hand itself has three more degrees of freedom: wrist roll, wrist flex, and hand roll.

These six motions, plus the grip, allow the robot to pick up an object of up to 4.5 kilograms (10 pounds) in any position and orientation within a 75 centimeter (2.5 feet) radius.

Industrial robots can be programmed in several different ways: continuous path teaching, point-to-point teaching, or use of a computer to solve the equations describing a desired trajectory.

The Scheinman Arm has electric motors, harmonic gear drives, and brakes on each joint. When the brakes are released, the joints can be backdriven. This allows the operator to literally "take the robot by the hand" and guide it through a series of desired movements. The computer records the position of each joint at fixed points in time and stores this information in memory for later playback. This type of "teaching" might be used to train a continuous trajectory robot to spray paint or fiberglass and to do arc welding.

More advanced types of control are possible by using a computer in the control system. Computer control allows the hand to move along straight lines, such as following an object along a moving conveyor belt or assembly line. Once a program is taught to the computer by any of the possible programming means, it can be recorded on a disk file and called up later for playback.

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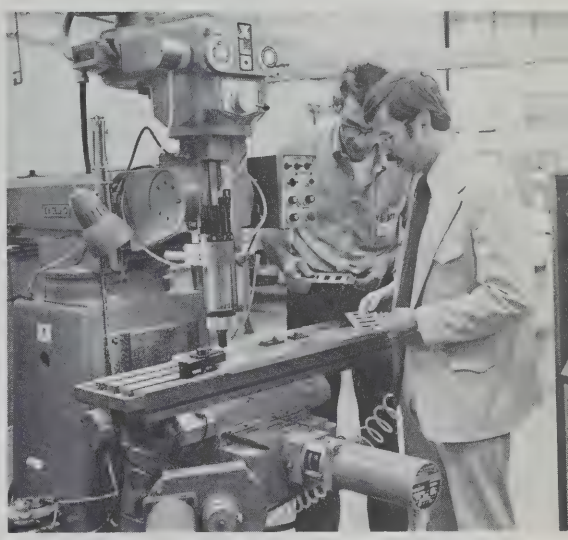
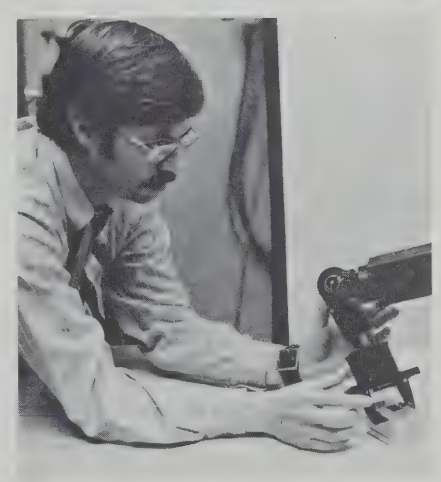




The six-axis robot will be used at NBS to load and unload parts for this two-axis vertical milling machine. NBS will concentrate on the hardware and software interfaces between the machine and the robot.

One way to program the Scheinman Arm is to literally "take it by the hand" and lead it through a series of desired movements.

Robot *continued*

Similar robots have been installed at Stanford University, the Jet Propulsion Laboratory of the National Aeronautics and Space Administration, and the Stanford Research Institute. NBS has distributed the basic procurement specifications for the robot to other government agencies to help them develop advanced computer controlled automation systems. The NBS procurement specifications have been modified by the General Motors Corporation for their own procurement of a similar system. Also, in anticipation of procuring a similar system for their own use, the Naval Research Laboratory has sent two guest workers to work part time with NBS developing software for the robot.

As part of its continuing efforts to stimulate and encourage the development and use of robot systems. NBS cosponsored the 5th International Symposium on Industrial Robots. The symposium, held September 22-24, 1975, in Chicago, brought together approximately 600 robotics experts from 10 countries to discuss applications of industrial robots as well as new research development. Fifteen industrial robots, from the U.S., Japan, Sweden, Norway, and Germany, were exhibited at the conference. □

The research robot has six different motions shoulder swivel, arm up and down, arm out and in, wrist roll, wrist flex, and hand roll, in addition to a grip

NBS, EPA to Offer Sound Level Meter Workshop

A 2-day workshop to provide instruction in the use of sound level meters used in the enforcement of Federal, state, and local noise regulations will be offered by the National Bureau of Standards in Gaithersburg, Md., on November 20-21, 1975.

The workshop, co-sponsored by NBS and the Office Noise Abatement and Control of the Environmental Protection Agency (EPA), will focus on the problems of enforcing or establishing compliance with noise regulations.

Topics to be covered in the workshop include:

1) The principles of operation and the acoustic and environmental properties of microphones of various construction;

2) The construction and operation of a sound level meter;

3) The causes and magnitudes of errors in data that are associated with sound level meter usage, including the effects of temperature, humidity, ground cover (asphalt, grass), obstacles (walls, people, tripods), and impulsive type sounds;

4) The calibration of sound level meters including the effects of temperature and barometric pressure on the calibration;

5) The statistical procedures to be applied to assure consistent and repeatable sets of data on noise.

A similar workshop was offered, by invitation only, in June. The workshop was developed through the coordinated efforts and joint support of the EPA Office of Noise Abatement and Control and the Office of Measurement Services and the Sound Section of the National Bureau of Standards.

Individuals interested in attending the November 20-21 workshop should write or call Dr. Edward B. Magrab, Chief, Sound Section, Building 233, NBS, Washington, D.C. 20234, 301/921-3607. The registration fee is $75. □

Health Care Delivery in Hospitals Being Aided

AN important and novel health care experiment has been started to encourage improved and more efficient health care delivery in American hospitals.

The experiment involves the commercial development and marketing of innovative health care products and systems by private firms. It is being conducted jointly by the Experimental Technology Incentives Program (ETIP), administered by the National Bureau of Standards, and the Veterans Administration (VA).

The objective of the experiment is to determine ways of using the Federal Government's purchasing power to stimulate the development and use

of improved health care equipment and supplies for the Nation's hospitals.

Health care delivery has become America's largest service industry. Estimated total expenditures currently are in excess of $98 billion annually. Hospital expenditures alone account for almost 40 percent of this total, with purchases of supplies, equipment systems, and contract services amounting to $7 billion annually. The largest single medical care system is that of the Veterans Administration.

The VA Supply Service supports the most extensive medical program in the Federal Government. A Marketing Center, three Supply Depots, and 168 Supply Services in field stations furnish support to about 250 VA installations and 400 other government agency installations.

Some specific examples of the projects to be undertaken in the ETIP-VA experiment include:

- Receive and implement approximately 25 specific procurement plans.
- Identify, experiment with, and evaluate new procurement policies and practices that provide incentives in Federal purchasing.
- Conduct an educational program with the VA hospital system to encourage increased participation in the procurement process by the end user of the product.
- Develop and participate in a coordinated system for the mutual exchange of medical device information between all levels of government and the private sector.
- Work with the medical devices branch of the Food and Drug Administration and other government agencies and the private sector to coordinate and interpret the myriad of health devices legislation.
- Provide comprehensive product information on testing, standards, specifications, procurement policies, and procedures to other health care organizations.

This experiment will be conducted over at least 3 years. The major result from this project is the creation of a functional entity within the VA to continue to experiment and test new procurement policies and practices that provide incentives to change in the area of health care delivery. All other results, such as experimental data on procurement effectiveness, innovations in products and systems, and improved health care delivery at a lower cost, will serve as the basis from which ETIP and the VA will jointly recommend policy to make the experimental procurement office concept part of the operating policy of the Supply Service.

For additional information about this program please contact: Frank Leach, Special Projects Officer, Veterans Administration, Washington, D.C. 20420 or Joseph Berke, Deputy Chief, Procurement Policy Area, ETIP, NBS, Washington, D.C. 20234. □

Symposium on Building Construction to be Held at NBS

A major symposium on building construction will be held at the National Bureau of Standards in Gaithersburg, Md., on March 24 and 25, 1976.

In addition to NBS, the sponsors of the symposium include the General Services Administration, the Air Force, the Department of Health, Education and Welfare, the U.S. Army Corps of Engineers, the National Aeronautics and Space Administration, the Veterans Administration, and the Office of Management and Budget.

The symposium is being preceded by workshops at three American universities. The workshops are focusing on providing building owners with information and ideas to save costs and enhance the quality of construction. These ideas will be discussed and refined at the symposium and will be printed and disseminated widely.

The first workshop, titled "The New Connection: Owners and Manufacturers," was held earlier this month at the University of Wisconsin School of Architecture in Milwaukee. It emphasized the cost and time benefits obtainable for owners through stronger and more direct relationships with manufacturers. Building subsystems, performance specifications, and product information systems were discussed.

The second workshop, "Long Term Economy: A Systematic Basis for the

turn page

Symposium *continued*

Construction, Operation, and Reuse of Buildings," will be held at Harvard University, Cambridge, Mass., November 3 and 4, 1975. This workshop will explore life cycle performance, cost analysis as practiced by various Federal agencies, influence of financing on total building cost, and reclamation of existing space.

The third workshop, "Alternative Processes in Building Procurement," will be held November 16 through 19, 1975, at the University of Illinois at Urbana-Champaign. It will explore improved methods of building procurement including new patterns of contractual linkages, bidding procedures, and construction management techniques.

Findings of the three workshops will be published in early 1976 and be made available to participants approximately 2 months in advance of the symposium at the National Bureau of Standards. The findings from the workshops will be reviewed at the symposium and recommendations made to provide better service and improved buildings for public and private owners across the Nation.

Further information may be obtained by contacting Harry Thompson or James Haecker, NBS, Washington, D.C. 20234, (301) 921-3233, or Elmer Edwards, Office of Continuing Education and Public Service, University of Illinois at Urbana-Champaign, 116 Illini Hall, Champaign, Ill. 61820. □

Elusive Pulses Measured

ADVANCES in communications, computers, electronics, lasers, and nuclear science are coming to depend more and more on our ability to control and interpret picosecond (10^{-12} second) events or pulses (ultrashort bursts of electromagnetic energy). Scientists and engineers in these fields need reliable pulse waveform data on single, repetitive, and step pulses that vary in transition (rise and fall) and delay (travel) time, amplitude, shape, and duration.

Currently, Drs. James Andrews and Robert Lawton of the National Bureau of Standards' Electromagnetics Division, Boulder, Colorado, Laboratories are developing measurement methods for electrical and optical pulse waveforms at the forefront in measurement accuracy.

Andrews recently completed an Automatic Pulse Measurement System (APMS) covering frequencies up to 18 gigahertz and time intervals down to 20 picoseconds. The system takes digital data from a sampling oscilloscope for processing by a minicomputer. It automatically measures the pulse-handling performance of broad frequency range antennas and microwave networks. NBS is considering an APMS service for picosecond pulses.

Lawton has developed a simple independent method, based on the pulse waveform autocorrelation, for measuring fast pulses. The pulse waveform to be evaluated and its delayed version are multiplied together in a pyroelectric device and the results summed over time. Using equipment he developed, Lawton says he can observe electrical pulses to 10 picoseconds resolution.

Andrews and Lawton have also designed another system, an optically strobed sampling oscilloscope for

electrical pulse information. Because a picosecond laser pulse lengthens when converted to an electrical pulse, Andrews and Lawton are trying to narrow the picosecond pulse generation gap to match the original laser pulse by using fast responding photoelectric devices. In the process, they have developed an electrically strobed sampling oscilloscope for optical pulse information.

For reliable picosecond transition-time pulses, Andrews has developed solid state pulse generators which can help evaluate short events, oscilloscopes, and receivers measuring radio interference. To retain their useful shape, pulses from the solid state devices are sent through a nearly lossless NBS superconducting line, arriving at their destination in their original form, and delayed in time because of the path traveled.

A compact 100-picosecond risetime waveform generator has also been designed that will convert short pulses of unknown risetime into somewhat longer pulses of known risetime. This waveform generator, a special lossy coaxial cable, provides well defined pulse waveforms for measuring events. By using different lossy liquids inside the coaxial cable, a variety of pulses are available. □

New Technique in Predicting Dry Weight

RESEARCH at the National Bureau of Standards has resulted in the development of a relatively simple, inexpensive, and rapid technique for assessing the dry weight of solids. Dry weight is determined by fitting vapor adsorption theory to experimental data by an unorthodox application of the least-squares method.

Using this technique, accurate dry weight predictions were obtained even when data were collected at relative humidities above 50 percent, making the approach particularly valuable for use in biological research where the viability of the organism could be destroyed by complete drying.

When dry weight predictions were compared with experimentally measured values for solids, agreement was within about 1 percent with the calculated weights usually on the low side.

The technique, developed by Dr. William V. Loebenstein of NBS' Dental and Medical Materials Section, is based on the assumption that adsorbed water is not water of constitution (water naturally bound to the solid) and, consequently, is excess. The precise point of dryness can be established, therefore, by determining the weight of the solid under conditions where the amount of physically adsorbed water would be zero.

Adsorption equipment with a circulatory flow system supplies water vapor in a carrier gas at predetermined humidities to the solid under investigation. This solid (the adsorbent) is carefully weighed and the exposure is repeated until no further change in weight establishes that equilibrium has been attained at each humidity. The weight of the solid is determined at a minimum of four different humidity values. These experimental points are obtained in either continually decreasing steps (desorption or drying), always beginning at the point of saturation, or in a continually increasing (adsorption) sequence. These same experimental points, which are commonly employed using least-squares methods to determine only the surface area of an adsorbent, can, at the same time, furnish its dry weight.

Dry weight determinations are accomplished by the convergence of a computer program employing a least-squares method applied to an appropriate isotherm equation. Loebenstein found the Brunauer, Emmett, and Teller and the Harkins and Jura equations to be applicable to the technique. These adsorption equations express the amount of vapor adsorbed per gram of samples as a function of relative pressure.

The NBS method may be of use in a variety of fields. Nondestructive determinations of dry weight could be useful in biological research, particularly in growth rate studies. Also, the technique might possibly provide a solution to the problem of determining moisture content in agricultural products (such as grains) and other materials where the last traces of water may be extremely slow coming off during drying. Surface chemists might find the technique a valuable aid for measuring water vapor on the surface of materials which decompose on drying. Its possible applications, in short, are as varied as the areas that require accurate predictions of dry weight. Loebenstein cautions, however, that before this technique is applied in these areas and others, researchers must first determine whether the isotherm equation employed is appropriate to the sample. □

CORRECTION

The article in September 1975 DIMENSIONS titled DETERMINING THE EFFECTS OF WEATHER ON BUILDING MATERIALS was written by Dr. Gerald Sleater and Larry Masters, researchers in the NBS Center for Building Technology. The editor regrets that credit to the authors was inadvertently omitted from the issue.

NOTE

The scanning radiometer discussed in DIMENSIONS/NBS (April 1975) was designed by Dr. Theordore H. Benzinger and built by Ernst Neumann, Harvey Breeden, Paul Lundberg, and Ralph Orwick under the supervision of Laslo Monostori of the NBS Instrument Shops.

NBS, ERDA Sign Agreement on Energy R&D

THE National Bureau of Standards and the Energy Research and Development Administration (ERDA) have signed a Memorandum of Understanding calling for interagency cooperation to enhance the national energy research and development effort.

The Memorandum of Understanding was signed on September 16, 1975, by Dr. Robert W. Fri, Deputy Administrator of ERDA, and Dr. Ambler, Acting Director of NBS.

Under terms of the agreement, ERDA and NBS management will identify specific problems related to physical measurements and standards in energy research and development which can be undertaken by NBS in support of ERDA programs.

In carrying out its responsibility for planning, developing, and coordinating a vigorous national program in energy research and development, ERDA will use the Nation's most capable scientific, engineering, and management resources in the public, private, and university sectors of the economy.

In signing the Memorandum of Understanding, NBS Acting Director Ambler noted that although ERDA will be using the technical capabilities of a number of Federal agencies, "NBS has a particularly important role to play in helping to solve the energy problems that we as a nation face today. As the Nation's largest physical science and measurement laboratory, NBS scientific and engineering personnel are engaged in the development of national standards of measurement, the determination of physical constants and properties of materials, and the development of methods of testing."

Ambler noted that these capabilities will be used by ERDA in three ways:

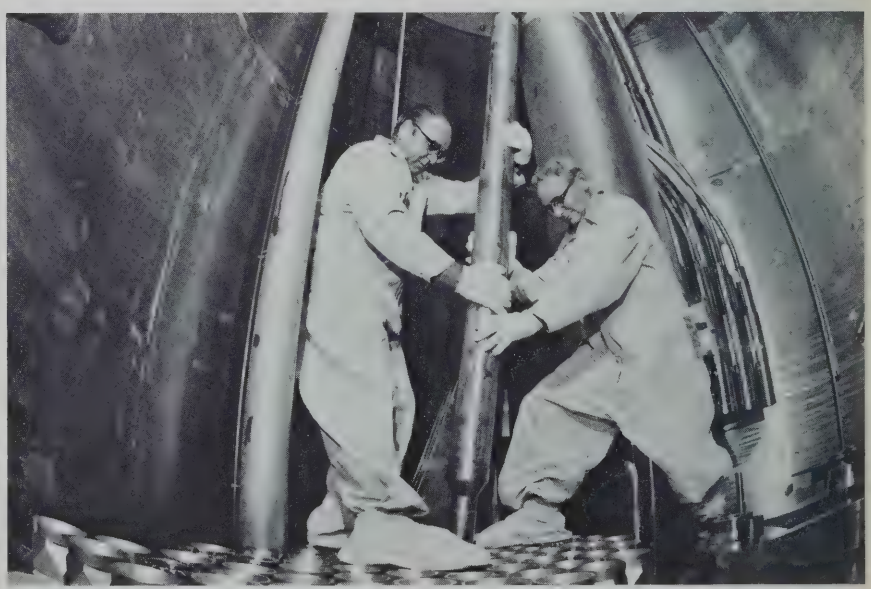
1. *Research and Technology*. NBS will conduct energy-related scientific and technical research at its laboratories in specific fields such as radioactivity standards; nuclear fuel measurements; atomic, molecular, and nuclear data for controlled thermonuclear research; materials evaluation for energy conversion systems; and energy conservation.

2. *Programs and Projects*. NBS will recommend to ERDA specific technological developments in the fields of standards, measurement methods, and technical data which would contribute to the successful attainment of ERDA program goals.

3. *Technical Advice*. NBS may be called upon by ERDA for technical advice in the evaluation of energy research and development programs, plans, and proposals.

Program coordinators for each agency will be designated to provide continuing liaison between the two agencies and to implement the Memorandum of Understanding. The coordinators will develop Interagency Agreements providing the operational and management guidelines and covering the specific programs or projects necessary to implement the Memorandum of Understanding.

In addition, each year the coordinators will conduct a joint review of NBS work in support of ERDA programs and develop plans for future efforts. Following such annual review, the Administrator of ERDA and Acting Director of NBS will provide guidance on the scope of NBS work for ERDA in light of ERDA energy R&D strategies and NBS plans. □



The field of nuclear fuel measurements is one of several areas to be addressed by NBS research under a new NBS/ERDA agreement. Shown above, fuel elements are placed in the core of a reactor.

With earmuffs, there are no complex fitting problems since one size fits most adults. On the other hand, earmuffs are bulky and can't fit in a pocket. They may not fit properly when glasses, hearing aids, or other personal items are worn. But they can be worn in spite of minor ear infections. In the winter they are warm and comfortable, but in warm weather heat and perspiration can make them distinctly uncomfortable. Earmuffs are harder to wash than earplugs. When used by groups on the firing range, earmuffs can be seen at a distance and supervisors can readily tell whether all the shooters are wearing protectors.

Cost comparisons indicate that plugs are less expensive than muffs, but if disposable plugs are used frequently they can be more expensive than muffs in the long run.

The overriding consideration in selecting and using hearing protectors is to make sure that the protector provides a good seal when placed in or over the ear. Hearing protectors made from the best noise attenuating materials would not be a good choice if some other factor, such as comfort or the need to wear eyeglasses, prevented one from obtaining an effective seal.

On questions of durability, cleanability, comfort, and price, the individual obviously has personal choices to make. Through judicious selection, everyone needing hearing protection on the firing range can readily obtain it at reasonable cost. To go without protection, on the other hand, would involve risking a most unreasonable cost—partial or total deafness, developing gradually but probably irreparably over a period of time. □

NOISE OF POPULAR FIREARMS MEASURED

In an effort to provide guidelines for law enforcement personnel to protect their hearing, the peak pressure level and signal duration of various popular firearms were measured by Pearl G. Weissler and Michael T. Kobal of the National Bureau of Standards. Results were compared with requirements of the Occupational Safety and Health Act (OSHA) of 1970, damage-risk criteria (DRC) of the Committee on Hearing, Bioacoustics and Biomechanics (CHABA), and levels established in 1974 by the Environmental Protection Agency (EPA).

Small condenser microphones and a storage oscilloscope were used to record the blast wave signature from a 9 mm automatic, a caliber .357 Magnum revolver, a caliber .41 Magnum revolver, a caliber .22 revolver, a caliber .45 automatic, a caliber .44 Magnum revolver, a 12 gauge shotgun, and a caliber .22 rifle.

Measurements were made at the ear of the person shooting and at the approximate position of a neighbor at a firing range. Some measurements were also made at a practice firing range. A portable tape recorder was found useful for recording gun signals and measuring durations. It was found that in an anechoic environment the noise from five of the handguns exceeded the CHABA DRC (1968), while the noise from all of the firearms tested, except the caliber .22 rifle, exceeded the EPA levels (1974). At a sound-insulated firing range, the noise from all the firearms tested, except the caliber .22 rifle, exceeded the CHABA DRC (1968), while all the firearms tested exceeded the EPA levels (1974).

STANDARD

An NBS-developed standard for "wearable devices used to protect the auditory system against the excessive sound encountered on firing ranges" was issued in 1973 by the Law Enforcement Assistance Administration's National Institute of Law Enforcement and Criminal Justice.

The standard — NILECJ-STD-0102.00 — establishes performance requirements and test methods for hearing protectors. Included is a method for measuring hearing protection by means of psychoacoustic tests on human subjects, based on a method long in use to evaluate protectors worn in situations marked by continuous, steady noise. An appendix discusses the state of the art with regard to measurement techniques applicable to the impulsive noise generated by firearms.

Order from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price: 40 cents, domestic postpaid. Stock No. 2700-00182.

of cooling which would otherwise be wasted was saved.

In the fourth project, the 50-year-old, poorly fitting windows on a satellite hospital were replaced with tight fitting, double-gazed windows. The energy saving for each window is expected to cut the present loss of energy by 85 percent per window. Westinghouse in East Pittsburgh estimated similar old windows in their plant cost $19 per year in wasted heat. The new installation in the hospital is expected to save $16 per year on each window. When you realize that there are several hundred windows involved, you can appreciate the tremendous savings in energy.

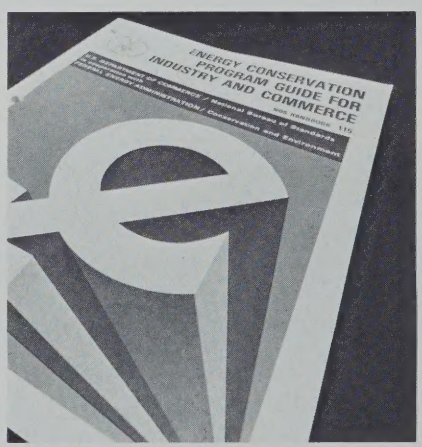
The latest word I have on this project is that the Veterans Administration plans to extend this energy conservation program to others of its installations.

MIUS Concept Studied

The Modular Integrated Utility System (MIUS) concept is being investigated by the U.S. Department of Housing and Urban Development (HUD). HUD's concept is directed toward providing housing developments of moderate size with energy, water, and waste disposal services from a single plant which balances service requirements with environmental quality, energy conservation, and low total costs. Although the HUD concept is geared toward housing developments, it has direct applicability to health care institutions that have similar needs. Let me demonstrate.

In 1970, HUD initiated an integrated utility demonstration project in Jersey City, New Jersey. The Jersey City project is a total energy plan, a key element of the MIUS concept. It has a total energy plant that generates electric power on-site and provides heating, cooling, and process heat from waste energy recovered from the production of electricity, a worthwhile consideration for hospitals that must have standby electric power generating capability in case of a power outage.

NBS is now measuring and evaluating for HUD the total energy plan in this housing development. A complete data collection and analysis system has been installed to measure the performance of a 3 megawatt power plant serving the electrical, heating, and cooling needs of a 484-dwelling unit apartment complex, a school, and a commercial building. A pneumatic trash collection system is also being evaluated. Other experimental integrated systems to be demonstrated include heat recovery, thermal storage, solar heating, and innovative electric power generation. This spring NBS started collecting data on the plan. We estimate that it will take about a year to collect and analyze these data. By the summer of 1976, we expect to publish reports on energy and economic savings resulting from the use of total energy at this site. We expect to have some interesting statistics.



Many suggestions in EPIC, a how-to energy conservation guide originally intended for business and industry, can be applied to hospitals.

MIUS Plan in Boston

A MIUS concept plan has also been proposed for a medical complex in Boston, Mass. Here, nine medical institutions in the Boston area have organized themselves into a corporation. Its purpose is to have one organization provide the nine institutions with services that would be more expensive if each instiution provided this service to itself. The corporation would supervise the planning and construction as well as own and operate the proposed service center and power plant. Areas of shared services would include utilities, procurement, material handling, and any other service that could be provided at less cost by a central organization. First priority is to be given to on-site generation of electric power, steam, and chilled water. The MIUS concept plan for this medical complex is now in its final design state. It is in the process of getting zoning and environmental approval from the local authorities.

These are examples of energy conservation which health care administrators may find useful to meet their own needs. Persons wishing additional information on these and other energy conservation projects may write to my office, Room B115, Technology Building, National Bureau of Standards. □

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